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ABSTRACT

To investigate the effect of several cueing methods on paired-associate learning, 48 adult subjects were asked to learn pairs of city names and corresponding airport codes using special cueing procedures or standard anticipation procedures. Visibility of the response term, and hence cue strength, was varied tachistoscopically, adjusting the illumination level. Tachistoscopic cueing produced signficant but not large improvement in learning. The procedures and results of the six experiments are discussed in detail. (EMH)

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SOME EFFECTS OF GRADUATED PARTIAL CUEING ON THE LEARNING OF PAIRED ASSOCIATES

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Some Effects of Graduated Partial Cueing on
the Learning of Paired Associates

Peter M. Guthrie and Arthur A. Lumsdaine
American Institute for Research
September 1961

ABSTRACT

This report describes a series of exploratory experiments conducted to investigate the effects of several cueing methods on paired-associates learning. In these experiments a total of 48 subjects learned the items in lists of city-names paired with corresponding airport-city codes, using special cueing procedures or standard anticipation procedures. The cues consisted in presenting the response terms under lowered conditions of visibility. Visibility, and hence cue strength, was varied tachistoscopically or gradually by adjusting illumination of the cue. Under conditions in which subjects had increasing amounts of time to anticipate the response terms, tachistoscopic cueing produced better learning than a comparable anticipation condition. However, the positive effects produced by this form of cueing were, though statistically significant, rather small. Furthermore, this form of partial prompting was not found to be superior to an immediate full prompt. These results are discussed in relation to needs for further study of graduated cueing techniques in the learning of paired-associate and continuous-discourse materials.

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SOME EFFECTS OF GRADUATED PARTIAL CUEING ON THE LEARNING OF PAIRED ASSOCIATES[1]

by

Peter M. Guthrie and Arthur A. Lumsdaine

Introduction

This series of exploratory experiments was undertaken to investigate whether partial disclosure of response terms as cues during acquisition of paired-associates (PA) lists can be used to facilitate learning, in comparison with uncued PA list-presentation methods. Standard methods for presenting paired associates involve presenting each pair of items to the subject (student) one at a time. Typically, the stimulus term (ST) is presented briefly, then ST and the response term (RT) are presented together for a short time. As the subject (S) begins to learn the pairs, he is instructed to anticipate the appearance of RT by saying the response (R) aloud as soon as ST is presented. He is then given a series of trials until he can anticipate each RT correctly. This technique may be termed the Anticipation Method (or--in the terminology used by Cook and Kendler (1956) and Cook (1958), the "confirmation" method).

An alternative technique consists in allowing S to simply study each pair of terms for some standard time over a series of trials. After N trials an Anticipation or unprompted test trial may be given to test S's knowledge of the list. This technique might be termed the Study Method, Prompting Method--or, to distinguish it from the partial-prompting techniques described below--the Full-Prompting Method. This is essentially the technique used by Cook and Kendler (1956) and Cook (1958) for "prompting" trials. Their

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[1]The experimental work reported here was performed in the summer of 1960 while the senior author, now at Carlton College, Northfield, Minnesota, held a temporary staff appointment at the Pittsburgh office of the American Institute for Research. The junior author is A.I.R. Research Adviser for Educational Media as well as Professor of Education at the University of California, Los Angeles.

results showed that using such full-prompting trials produced more rapid acquisition than did otherwise comparable confimation trials. In the further comparison by Angell and Lumsdaine (1960), such full prompts were used on all trials for one group to compare with the mixture of full prompt trials and unprompted anticipation (or test) trials that had been used by Cook and collaborators in their prompting condition. (The mixture of trial types, in the Cook-Kendler studies, resulted from the use of interspersed test trials which they inserted after every three training trials to permit plotting of acquisition curves.) Such a mixture of prompted and unprompted trials (which Angell and Lumsdaine found superior to uniform use of full prompting on all trials) can, in a sense, be considered (as integrated over a series of trials) to be analagous to "partial prompting" conditions, even though the degree of prompting within any one trial is--unlike the present experiments--given on an all-or-none basis.

Partial cueing methods. In contrast to "all-or-none" cueing procedures, the cueing methods introduced in this study involved presenting ST for a time before the appearance of RT, but in addition presenting a weakened version of RT as a cue for the correct elicitation of the response, "R." Thus, the presentation of each pair within a list would consist of the presentation of ST followed immediately, or after some predetermined interval, by a "partial" cue for R and finally by full presentation of RT.

While current theories of learning are not unequivocal about how effective such a method may be, there are theoretical considerations to suggest that such a technique might produce substantially better PA learning than either the Study or Anticipation methods. Since the task of the learner is to become able to respond with R reliably when only ST is presented, the use of partial cues in the manner described can be thought of as providing a graded series of trials on which S comes to rely less and less heavily upon RT (considered as a stimulus) and more and more strongly upon ST as his signal for giving R. Skinner (1958) has suggested the term "vanishing" for this process of weaning S away from seeing RT as the necessary prompt for giving R as a response.

A more detailed theoretical formulation of an optimal rationale for vanishing has been described by Lumsdaine (1959), who postulated that conditions should be arranged so that learner would respond, at any point in a learning sequence, to the minimum cue-strength necessary to evoke the correct response at that point. Lumsdaine further illustrated how such an optimal vanishing gradient could be generated if provision were made on each trial for graduated partial cueing in which cue-strength would be gradually increased (e.g., by optically "fading in" the cue) up to the point where the learner was just able to respond. As learning progressed, the cue-strength needed would progressively diminish as the student was able to respond with less and less help.

The present experiments were designed to compare paired-associates learning under Anticipation conditions with paired-associates learning under several varieties of cueing conditions relevant to this general rationale. It was not expected that these experiments would provide any final answers; rather, they were aimed at exploring several cueing techniques which might appear promising as leads for further and more definitive research.

General plan of the experiments. All of the studies to be described follow the same basic design, which will therefore be described here in detail. Where individual experiments differ, the differences will be listed under the appropriate experiment. The overall study consisted of six small experiments, each of which involved one or more experimental comparisons. The basic design of these small experiments required a randomly assigned sample of Ss to learn either four or eight lists of paired associates. Half of the lists were typically learned under an experimental, partial-cueing, condition and half under a control condition. The order of these conditions was counterbalanced within each experiment so that half of the Ss learned in the order CEEC and half in the order ECCE (where E stands for experimental condition and C for control condition). In addition, the actual lists were counterbalanced as fully as was practical with limited sizes of samples. This design permits exploratory experiments with a small number of Ss by having each S serve as his own control, and at the same time permits some evaluation of inter-subject variability. It also provides some control of practice effects.

Materials, Subjects and Experimental Arrangements

Stimulus materials. The lists were composed of 16 pairs of city names and airport-city codes drawn randomly from the international listing of the Official Airlines Guide. The city-names, e.g., Los Angeles, Calif., U.S.A., served as stimulus terms and the codes, e.g., LAX, as response terms. Each pair in each list was typed in IBM "Executive" type (capitals being ¼" high) on standard 3 x 5" white file cards. The city-name was typed in upper and lower case letters (see above) across the five-inch dimension of each card and slightly above a line along the middle of the card. The code was typed in capitals just below this line, and centered laterally on the card. However, a 1½-inch piece of a second file card was glued over the bottom of the typed card so as to cover the code letters. Thus, when the cards were viewed with overhead lighting, only ST was visible, but when backlighted the code became visible too. The degree of its visibility could, also, be varied by adjusting the amount of backlighting. In Experiments I and II, the distance between the bottom of the stimulus term and the top of the response term was about one inch. For later experiments in the series, this distance was decreased to about one-eighth inch.

Apparatus. The apparatus consisted in three main components: a viewer for presenting the stimulus materials; a device for controlling cue presentation; and a means of timing the presentation of items and of recording the latencies of the Ss' responses. The viewer is shown in Figure 1. It was a corrugated cardboard box provided with a chute for sliding the stimulus cards over a window. With a card in position over the window, the ST was fully visible to S, seated in front of the box. In this position, the card rested on the edge of the window sill. A bar, similar to a spacing bar on a typewriter, connected to the window itself, could be depressed by S to allow the stimulus card to drop into the interior of the viewer. A large, light-tight door at the rear of the viewer permitted the experimenter (E) to retrieve the cards from inside the box once a list was completed. The panel of the viewer facing S was 12½ inches across the base and sloped up and back to a height of 9 inches. The window was 5 1/8 inches wide at the bottom. The viewer box was securely taped to a table to prevent changes in its position during experimentation.

Variation of cue strength: fade-in. Two means were provided for varying cue strength. A 25-watt frosted white light bulb was mounted inside the viewer so that the top of the bulb came to within ½" of the window. Thus, when this light was on and a stimulus card in place, the code letters were backlighted and clearly visible to S. Wired in series with the light were a Superior 10-B Powerstat and a foot switch. The Powerstat was mounted on the right-hand wall of the viewer so that its control knob projected outside the box. By rotating this knob, either S or E could vary the output of the light from 0 watts to the full 25-watt output. Special dials were made up for the various experiments so that E could control the output of the light, and hence the strength of the cue, fairly

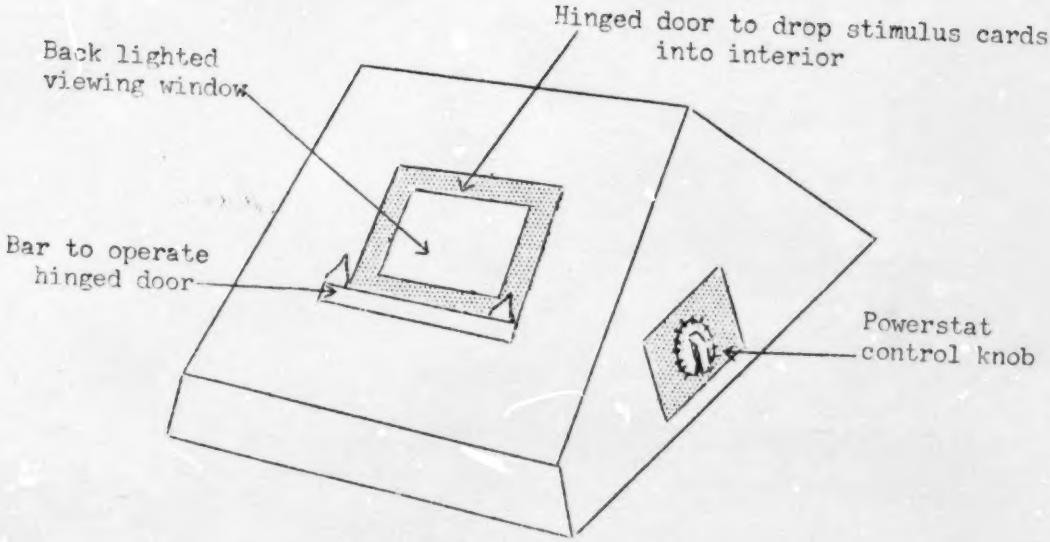
Hinged door to drop stimulus cards into interior
Back lighted viewing window
Bar to operate hinged door
Powerstat control knob

Fig. 1. The Viewing Apparatus

accurately. It was thus possible to "fade in" the cue at fairly uniform rates. The approximate threshold for accurate reading of the cue was located by a modified method of limits for three Ss before experimentation began.

Tachistoscopic cue presentation. The second method for presenting the cue used a form of tachistoscopic presentation giving a "quick flash" of the cue. By means of the foot switch, E could flash the light briefly, thus exposing the cue. It was found that the three experimenters were able to flash the light with fair reliability for periods as short as 0.25 seconds and quite reliably for durations of 0.5 seconds.

To control the timing of stimulus presentations and response latencies, a series of clicks produced by an electric metronome was recorded on tape. This series, when fed to E through headphones, permitted consistent timing of the card and cue presentations and of the latencies of responses made by S. Thus, when E was ready to start a trial he listened to the clicks and began counting them at some arbitrary point. Typically, he placed a stimulus card in position facing S on the "count" of one. If S responded correctly, E recorded the "count" just following S's response. Thus a response made during the first second of ST exposure would be recorded as having a latency count of two. After considerable practice, Es became fairly skilled at presenting the stimuli, recording counts and manipulating cues in a reliable manner.

Subjects. The subjects were volunteers, aged 16 to 35 years. The majority were persons who had listed themselves for summer employment with the Placement Offices of the University of Pittsburgh or Carnegie Institute of Technology. A few of the Ss were full time or part-time employees of the American Institute for Research in Pittsburgh. All were naive with respect to the specific purpose of the experiment in which they participated, but some had previously learned PA lists for psychology courses. The group ranged from the high school level to graduate school level of education. All Ss except the A.I.R. employees were paid a standard amount for their services. With the exception of three instances in which Ss failed to report for their appointments, the list of volunteers was first obtained and then these persons were randomly assigned to the various groups within the experiments. When an S failed to report, he was replaced by the next volunteer. In all, 48 Ss were used in the experiments.

Experimental situation. All of the studies were conducted in a windowless room about 22 feet long and 15 feet wide. The actual experimentation was done in plywood booths 6 feet long, 5 feet wide and 8 feet high. These were equipped with a small table and two chairs. Four such booths were built along one long wall of the experimental room. Only the two end booths were used for the experimental learning trials reported here; the two center booths were used for storage and as a reading room for Ss between lists. The two experimental booths were lighted by a single 40-watt white fluorescent bulb mounted on the ceiling directly over S. To reduce this illumination somewhat, each bulb was screened with a sheet of brown

wrapping paper. The resulting light was quite adequate for S to see the stimulus materials clearly but insured that he could not see the codes unless they were intentionally exposed by E. To provide ventilation and to mask extraneous sounds, two oscillating floor fans were run continuously during the experiments. In addition a screen was placed in the outer doorway to reduce sounds emanating from offices in adjoining rooms. While some extraneous sound did reach the experimental booths, no Ss complained of being distracted by them.

Instructions. As each S arrived at the experimental room, he was seated in one of the booths and was read a set of prepared instructions by E. All Ss were first read a set of general instructions to acquaint them with the nature of the task. Then special instructions were read to the Ss for each of the various experimental groups. These instructions are reproduced in a separate technical appendix (available on request). When the instructions had been read, S was asked to state the relevant points in his own words. He was then given several trials with the practice list to insure that he understood the procedure.

EXPERIMENT I

The purpose of the first experiment was to compare the effectiveness of tachistoscopic and fade-in cueing methods with a standard anticipation method of paired-associate learning. In addition, each of these comparisons was made under two conditions of intra-item time interval. The experimental design thus required four groups. Each S in each group learned four paired-associates lists, two under an experimental condition and two under an appropriate control condition. The order of conditions was counterbalanced within groups so that half of the group learned the lists in CEEC order and half in ECCE order. While complete counterbalancing of the actual lists was not possible, each list was learned by some Ss under control conditions and by some under the experimental conditions, which are further described below. Table 1, on page 8, shows this design.

Subjects, apparatus and materials. The Ss were 16 student-aged volunteers (see Introduction section, above), each of whom was asked to report to the A.I.R. Office at the same appointed time on two successive days. The equipment used consisted in two complete sets of the apparatus described above, with the one modification that a graded density filter was placed over the window in the viewer box. This filter, made of white file-card material, was

Table 1

The Design of Experiment I

Subjects	List Order	Condition of response: Experimental Condition	Condition of response: Control Condition
1	CEEC		
2	CEEC	6-Second Pro-	6-Second
3	ECCE	grammed Fade-In*	Anticipation
4	ECCE		
5	CEEC		
6	CEEC	6-Second,	6-Second
7	ECCE	Quick Flash	Anticipation
8	ECCE		
9	CEEC		
10	CEEC	8-Second Pro-	8-Second
11	ECCE	grammed Fade-In*	Anticipation
12	ECCE		
13	CEEC		
14	CEEC	8-Second,	8-Second
15	ECCE	Quick Flash	Anticipation
16	ECCE		

*Controlled by E

arranged so that when a stimulus card was in viewing position and the cue was exposed by lighting the box, the left-hand (first) letter of the code was most clearly visible. All three letters were, however, discernible when the viewer light was at full intensity. Four 16-item paired-associates lists of randomly drawn city-code pairs were used. In addition, a practice list of five adjective-number pairs was used to familiarize Ss with the procedure. The pairs in each list were lightly color-coded on the backs and numbered for easy identification by E.

Experimental Conditions and Procedure

The first regular trial was identical under all conditions. E presented each stimulus card for one second, then turned on the viewer light exposing the code; ST and RT were exposed together for three seconds, and then the viewer light was turned off and S was

instructed to "drop" the card into the viewer by pressing the drop bar. The interval between the drop and the presentation of the next card was approximately four seconds. Because the procedures on later trials differed for the four groups they are described separately below.

6-Second Fade-In. Following their first trial, Ss in this condition were given five additional trials, thus making a total of six trials through the list. On Trial Two, E placed ST in the viewer and turned on the viewer light, but at an intensity just below threshold, and simultaneously began rotating the Powerstat knob at a roughly constant rate to increase the strength of the cue. Since the dial on the Powerstat was specially calibrated in "counts" E was able to rotate the knob from threshold to full strength in six seconds by making sure to move the knob indicator past the appropriate dial setting at each count. As soon as S could respond, he tapped E's hand with a pencil, and immediately spelled the code aloud. E recorded the count immediately following S's tap. Whether or not S responded correctly during this period, E let the code remain fully exposed for two seconds, then turned out the light as a signal to S to drop the card. On the sixth trial, the order in which the pairs in each list were presented was changed to insure that learning had not been serial. Following the sixth trial, S was allowed a five-minute break. After the rest, S learned a second list, which concluded a day's session.

6-Second Anticipation Control. The procedure under the control condition was identical with that under the 6-Second Fade-In condition except that following the first trial, S received five trials in which each ST was presented for six seconds during which S attempted to anticipate the correct RT without cue. At the end of each 6-second anticipation interval E exposed RT fully for two seconds. The sixth trial was the same except that the cards were presented in mixed order.

8-Second Fade-In Condition. This condition and its control were similar in every way to the 6-second condition except that the cue was faded in over an 8-second period; or under the control condition, S was allowed eight seconds in which to try to anticipate the correct RT.

6-Second Quick Flash. Following the regular first trial, E presented ST on the second trial on the count of "one." S then had four seconds in which to attempt a response. If he did respond correctly, E simply exposed RT for two seconds at the end of the 6-second anticipation interval and recorded the latency of this response. When S could not respond, at the count of "five" E flashed the viewer light for approximately half a second. Subjects were instructed to give the correct response as soon as this "cue" had been presented. On Trials Three, Four, Five and Six, the procedure was the same save that the duration of the light flash was 0.25 seconds (approximately) rather than 0.5 seconds.

6-Second Anticipation Control. The comparison condition for Ss in the 6-Second Quick Flash group was identical with that for the 6-Second Fade-In group.

8-Second Quick Flash. This condition was identical with the 6-Second Quick Flash except that when the cue was provided it was presented at the count of "seven" instead of the count of "five."

With the exception of one S, all Ss learned two lists a day; one experimental and one control. (One S, who replaced a student who failed to return for his second day's appointment, learned all four lists on the same day.) The 16 Ss were run in two squads with 8 Ss, two per group, in each squad. Because the mechanics of the procedure followed by E were complex, the protocols for the first and second squads differed slightly. With the second set of eight Ss, the final (sixth) trial was a test trial on which the stimuli were presented in mixed order and all tests were made with the appropriate anticipation condition in effect. During the running of the first squad, one E gave immediate confirmation of all correct responses under all four conditions. The other E delayed confirmation until the end of the 6- or 8-second interval. With the second set of eight Ss, both Es confirmed at the end of the 6- or 8-second intervals.

Results of Experiment I

The basic response measures were: (1) the number of items given correctly and before the cue was above threshold on the final trial, and (2) the count on which each correct response was given on test trials and during acquisition. For the first squad, only test-trial responses which occurred with counts less than "five" were tallied as correct in the 8-second groups including the control conditions, since by the count of 5 the cue was above threshold. The count of "five" was also used for the 6-Second Quick Flash (QF) conditions since that was the count on which the cue was presented. For the second squad, no such correction was necessary, since all the final (sixth) trials were given under the Anticipation condition.

As an additional check on the comparability of the two squads, an analysis of variance was made upon the control-condition responding. With each S contributing one number, the sum of his test-trial items correct with both control lists, F fails to achieve a

significant level. For this reason, the data from both squads were pooled to provide an N of four in each of the four groups.

Table 2 presents the mean values obtained. It should be noted that direct comparison is possible with inter-subject variability controlled between mean correct test-trial responses for control versus experimental conditions within each group. However, since no matching has been introduced among groups, the group to group comparisons are not sensitive enough to be of much value with the small Ns here involved.

Table 2

Mean Number of Correct Responses on Trial Six for Each of the Four Groups in Experiment I

Groups	Condition		Difference (E-C)
	Experimental	Control	
Six-Second Fade-In	12.25	12.12	0.13
Six-Second Quick Flash	10.50	11.62	-1.12
Eight-Second Fade-In	10.00	8.62	1.38
Eight-Second Quick Flash	14.75	14.50	0.25

To determine whether the experimental conditions had affected test-trial responding, separate analyses of variance were made of the results in each of the four groups. A three-part analysis of variance was used. Using the residual mean square as error term, none of the F ratios for experimental versus control treatments were statistically significant at the .05 level. The separate residual mean squares were small in comparison to the between-subjects mean squares, suggesting little interaction between subjects and conditions though relatively high inter-subject variability.

The performances of individual Ss showed no consistent trends. All four Ss in the QF-6 group performed better under the control condition. In each of the Fade-In groups, three Ss performed better under the Fade-In than under the matched control condition.

Figure 2 shows the means of the median counts indicating latency for all correct responses on Trials Two through Six. In considering Figure 2, it should be recalled that cueing under the Fade-In (FI) conditions began immediately, and that the cue was presented on the counts of "five" and "seven" for the QF-6 and QF-8 conditions respectively. No statistical tests of significance were made of these latency data because of the variability in protocols followed by the two Es and because the different "ceilings" imposed on correct responding made interpretation unclear. The two graphs (A and C in Figure 2) of responding under the Fade-In conditions suggest, however, that Ss did respond faster as practice increased. Examination of the individual data sheets also shows this relationship, although it is not entirely consistent. There appeared to be fairly wide individual differences in response latency characteristics.

Although none of the experimental methods tried in the experiment produced significantly better performance than control conditions, the study suggested two things. First, the tachistoscopic (QF) conditions proved relatively useless in the absence of a ready signal to tell S that a cue was about to appear; many Ss reported missing the flash when it was given. Second, several Ss reported feeling that the Fade-In condition would be more satisfactory if S were allowed to manipulate the cue himself.

Finally, when scores on test trials are arranged according to the order in which the lists were learned, a small but orderly practice effect appears, indicating the worth of employing the counterbalanced-order procedure. (The means for all groups over the four lists are: 11.1, 11.6, 11.7 and 13.0.)

EXPERIMENT II

Experiment II was a very small pilot study to see whether or not the suggestions made by Ss in Experiment I might improve the same two cueing methods. While the design of the basic experiment remained the same, only four Ss and two experimental conditions were used. One condition was an 8-Second QF "Hold" condition (see below) with a ready signal included to tell S that the cue was about to occur. The other experimental condition was a Voluntary Fade-In condition (VFI). An 8-Second Anticipation condition provided the control comparison.

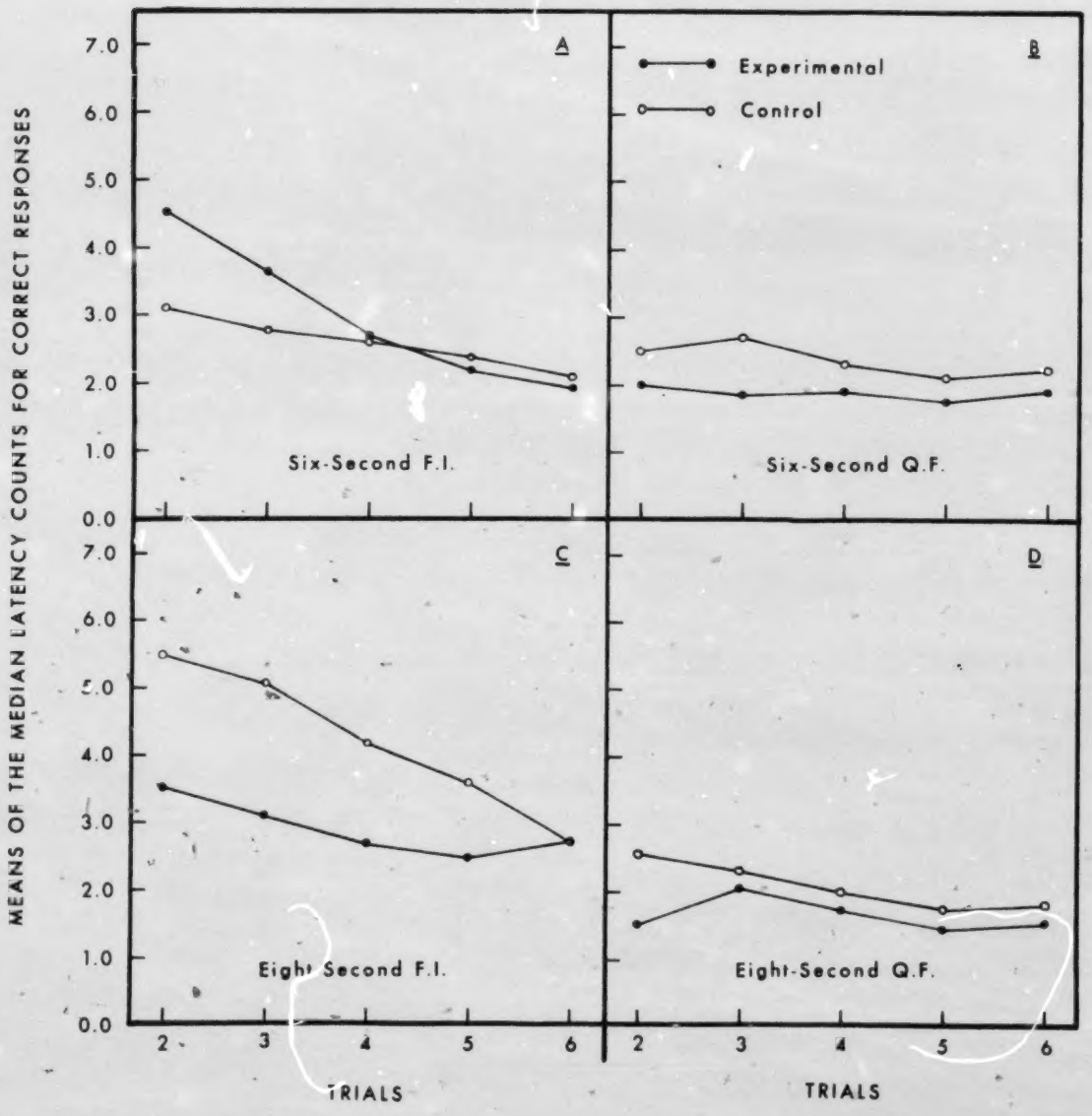

Fig. 2. Latency data for correct responses in Experiment 1 (on Trials 2, 3, 4, 5 and 6, for the four experimental groups).

Subjects and Procedure

Four volunteers from the same population as sampled in Experiment I were used as Ss. Two Ss were randomly assigned to each group. Each S learned two lists on each of two days. The equipment used in Experiment II was the same as that used in the first experiment. A new set of instructions, appropriate to the changed conditions, was used. The first regular trial under all conditions was identical with first trials in the previous study.

Experimental Conditions

Voluntary Fade-In. The second trial under the VFI condition allowed S unlimited time to attempt anticipation of RT once ST was presented. When S could not recall the correct response, he began fading in the cue from a subthreshold level by rotating the Powerstat knob until he could give the correct response. As soon as S had responded correctly, E recorded the count and the dial setting and simultaneously exposed RT fully. Thus S had an opportunity to respond without cue, but could use as much or as little cue as necessary to prompt a correct response. Each S received six trials, the last trial being an anticipation trial with the pairs in mixed order. The control condition was an anticipation condition similar to Experiment I.

Quick Flash 8-Hold. This method differed in several ways from the QF condition in Experiment I. First, after S had heard the instructions, worked with the practice list and had one regular first trial, E presented ST alone on the count of "one." On the count of "two," E said, "ready," and on the count of "three" flashed the cue at full intensity for 0.5 seconds. Subjects were instructed to withhold any response, including uncued anticipations, until E said, "respond" on the count of "seven." (In the instructions, Ss were told to scan ST during the period between the cue and the count of "seven.") The intention here was to insure that S would: (1) respond correctly on each trial, (2) have several seconds to study ST with RT "in mind," and (3) respond overtly with only ST present. As soon as S had responded, E presented RT fully for two seconds and then signalled S to drop the card. Six trials were given; the sixth trial was a regular test trial with the pairs in mixed order and no cue present. The control condition was a regular 8-Second Anticipation condition in which S received six trials, the last one being a regular test trial.

Results of Experiment II

The main contribution of this study was in showing that with a ready signal added, tachistoscopic cueing appeared to be a practical method; subjects in the QF-Hold group did as well or better under this condition as under the 8-Second Anticipation condition. The Ss under the VFI condition showed great variability in the amount

of time they used in attempting to anticipate; one S in the VFI group performed better on the test trials under the VFI condition and the other S did better under the control condition. Experiment III was designed to provide additional data on the QF technique and on an experimenter-controlled fade-in method.

EXPERIMENT III

In the light of the results of Experiments I and II, it was decided that two modifications of the QF method and one modification of the FI method would be tested. The modifications consisted mainly in allowing Ss increasing amounts of time to attempt anticipation of RT, while at the same time giving them the benefit of a cue. Three groups were included. As in the previous experiments, Ss in each group learned four lists, two under an experimental and two under a control condition.

Subjects and Apparatus

Twelve Ss from the population previously described were randomly assigned to the three experimental groups. One minor change in the viewing apparatus for this experiment was that the graded density filter over the viewer window was exchanged for a uniform density filter. This change was made to insure that Ss in the QF conditions would be able to see the code clearly whenever it was flashed.

Experimental Conditions and Procedure

Three new sets of instructions were used. In this experiment only five trials were given, in order to reduce the number of Ss who might learn both experimental and control lists completely by the test trial. The first trial under all conditions was the same as in previous experiments. Each test trial was identical and consisted in an 8-second anticipation trial with stimulus cards in mixed order.

QF 8-Hold with Progressive Time to Anticipate (QF-8-P). Under this experimental condition, Ss were told not to attempt anticipating RT on Trial Two. Instead, E presented ST on the count of "one," said "ready" on the count of "two," and exposed RT fully for 0.5 seconds on the count of "three." S withheld his overt reaction to the cue until, on the count of "seven," E said "respond!" Trial Three was similar, but S had two seconds in which to attempt anticipating before E said "ready." On Trial Four, S was allowed three seconds to attempt anticipating before the cue was flashed. On all trials, E exposed RT fully for two seconds after the initial

8-second period. Whenever S did anticipate correctly, E recorded the time count. The counts for all test-trial responses were also recorded. The comparison condition consisted in a regular 8-second anticipation condition.

QF 8-Hold with No Opportunity to Anticipate (QF-8-H). To provide some measure of the effect of progressively increasing the amount of time allowed to anticipate under the first QF condition, Ss in this group were given a QF-8 procedure with the cue flashed for 0.5 seconds on the count of "three" on every trial, but were instructed not to attempt anticipating. Instead, they simply withheld their response until E said "respond!" on the count of "seven." As in the first condition, all Ss had one regular first trial, then three trials with the experimental condition operating and a final test trial. A record of response latencies was kept only on the final test trial. A regular 8-second anticipation control condition was used for this group.

FI-8 With Progressive Opportunity to Respond Without Cue (FI-8-P). Following a regular first trial, Ss under this condition received three trials on which they were given three seconds in which to respond to ST without cue. When they did so, E did not present any cue, but did confirm their response at the end of the 8-second interval by a two-second full exposure of RT. When S could not respond within three seconds of ST presentation, E faded in the cue at a rate such as to shift cue strength from just below threshold to full intensity in three, four or five seconds on Trials Two, Three and Four respectively. When S did respond to the cue, E recorded the latency (count). The fifth trial under this condition was a test trial, and the control condition was a regular 8-second anticipation presentation.

Results of Experiment III

As in Experiment I, this study consisted of several separate subexperiments. Therefore, while a rough comparison of the effectiveness of the three experimental conditions is possible, the design provides primarily for controlled comparison between each experimental condition and its own control.

Figure 3A shows the mean number of correct test-trial responses made under both conditions in each of the three groups. In each instance, responding under the cued condition is superior to that under the corresponding control condition. To test the significance of these differences, a three-part analysis of variance was run on each of the three sets of data using the mean number of items correct on test trials for each S. While residual mean squares were small, none of the F ratios had a p-value of less than .05.

Figure 3B shows the means of the median counts for Ss under the

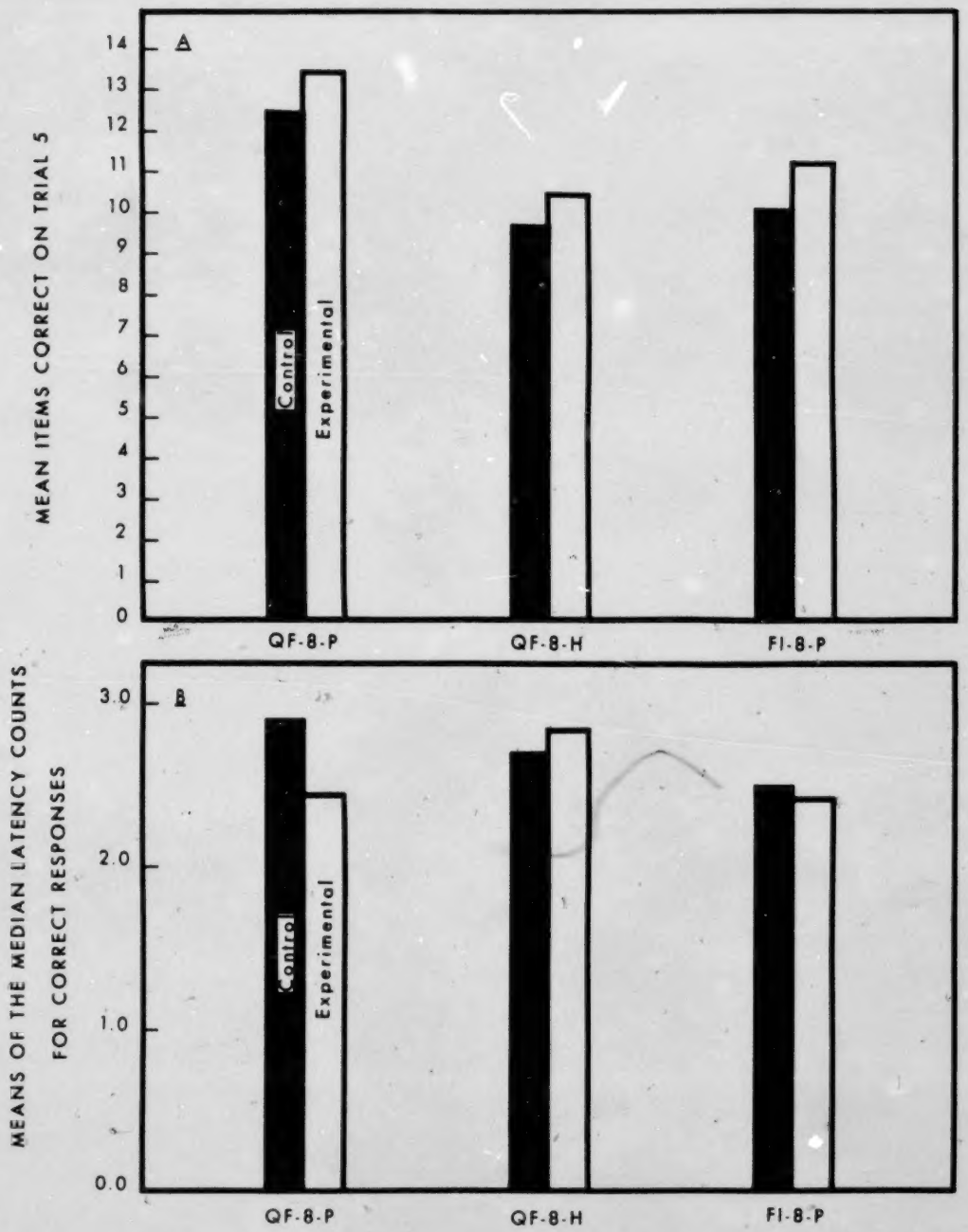

Fig. 3. Correct responses for three groups in Experiment III. (Upper graph shows mean items correct on Test Trial 5; lower graph shows means of median counts for correct responses on test trials.)

various conditions on the final test trial. Three-part analyses of variance applied to these data showed that Ss in the QF-8 Progressive Time to Anticipate condition were responding at significantly faster speeds than under their control condition. ($.05 > P > .02$). In neither of the other two groups were differences reliable by this test.

As a further check on what was occurring in the FI-8 group during acquisition, the cumulative frequencies with which correct responses occurred on Trials Two through Five were plotted as a function of "count." Figure 4 shows this relationship. These curves are based on all correct responses regardless of when during the intra-item interval they occurred. Thus, in Figure 4A all responses under the experimental condition that occurred within the count of "four" are uncued. All responses with longer counts involved the possibility of cueing. Under the experimental condition, Ss were making many more correct cued responses during acquisition than uncued responses under the control condition. But when, on Trial Five, the cue was omitted, the distributions of correct responses under both conditions were remarkably similar.

The general results of this experiment, while failing to show a statistically reliable superiority of experimental over control responding nevertheless suggested some slight favoring of the experimental techniques. As a follow-up, in two of the subsequent studies the conditions used in the QF-8 Progressive condition in Experiment III were replicated in Experiment IV to provide an increased N for this condition. In addition, several other cueing methods were tried to provide somewhat wider sampling of cueing methods.

EXPERIMENT IV

This experiment was a replication of the QF-8 Progressive condition used in Experiment III. This study, together with the results of a portion of Experiment VI, provide additional evidence concerning the effectiveness of the QF-8 Progressive condition. Eight Ss from the same sources as in the previous experiments were run under a QF-8 Progressive Opportunity to Anticipate condition. Care was taken to insure that all conditions would be as similar as possible to those used for this group in Experiment III.

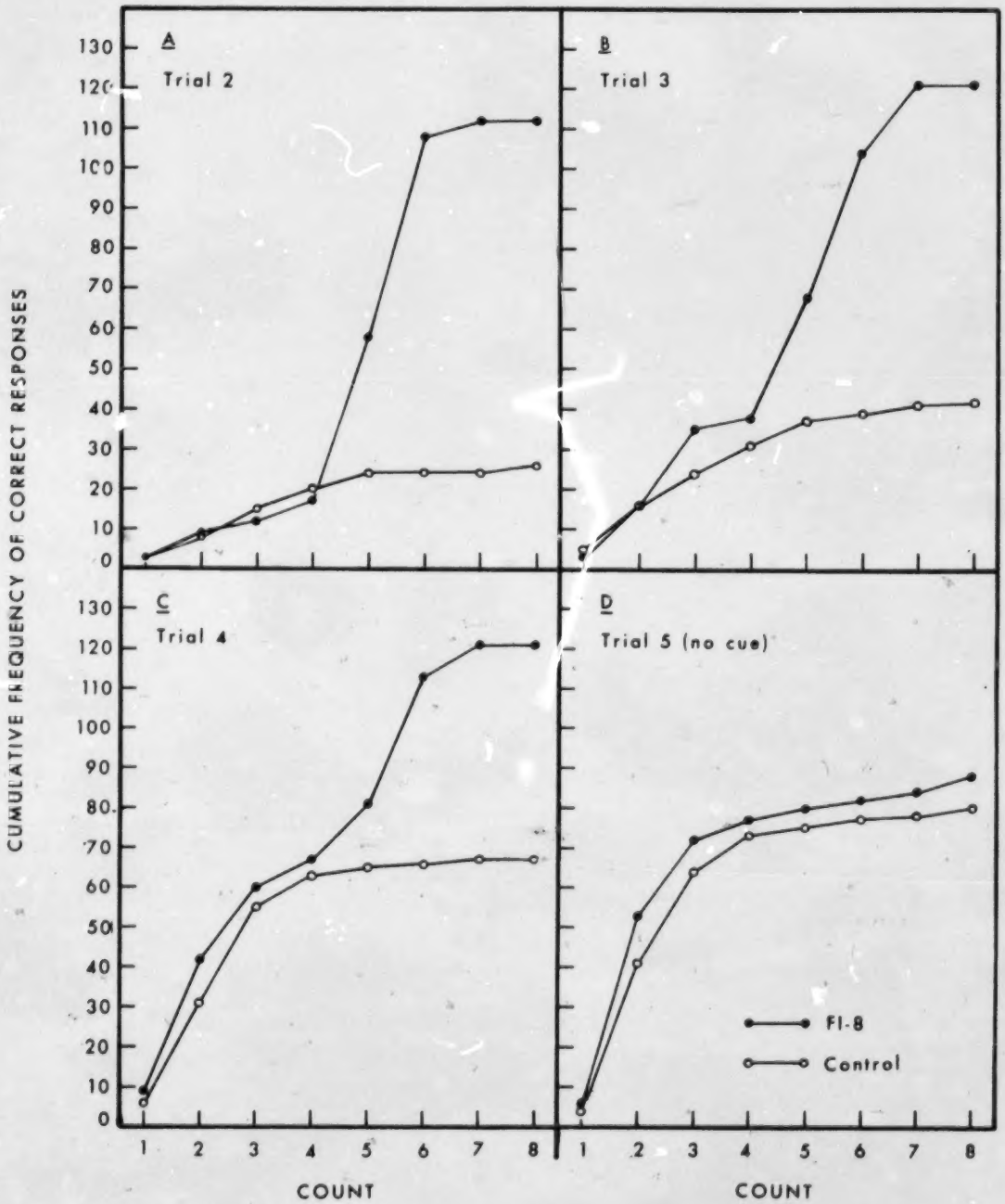

Fig. 4. Cumulative frequency distributions for Experiment III. (Correct responses made by Ss in the FI-8 group on Trials 2, 3, 4, and 5 at various time-counts during the intra-item intervals.)

Results of Experiment IV

The mean number of items correct on the final test trial for the eight Ss in this group were 12.0 under the QF-8 condition and 12.2 under the control condition. This slight difference is, of course, not significant (t-test for paired observations). Additional analyses of the numbers of individual code letters correct on the test trial under each condition also failed to show any reliable difference. Also, analyses of responding during acquisition, when corrections for the time limit imposed by the cue were made, show no substantial differences between the two methods.

Thus, while the results with this QF-8 condition in Experiment III tended to favor (though not significantly) the experimental condition, the results of the present experiment were entirely neutral. However, the outcome of a third experiment (see Experiment VI, below) was a statistically reliable difference in number of correct test-trial responses under the QF condition.

EXPERIMENT V

The fifth experiment in this series was a minor one involving four Ss. It was designed to compare the effectiveness of a prompting condition in which the strength of a delayed prompt, provided with each item, was determined by the latency with which S had responded on the previous trial, with a delayed, full-prompt control condition. Assuming that the rapidity of response is related to the ease with which a given response is emitted under the stimulus conditions, a short latency indicates an easier item.

Procedure

Four Ss from the population previously described were used. All equipment and stimulus materials were the same ones used in the previous studies. Under the experimental condition, the first trial was a regular one with ST and RT paired, as previously described. On Trials Two, Three and Four, ST was exposed for three seconds and then RT was also exposed for five seconds. However, the intensity of the viewer light was set at a value determined by the latency of S's response to RT on the preceding trial. Thus, on the first trial, E recorded the count on which S responded to each RT (as a stimulus). On the second trial, before exposing RT, E set the

Powerstat knob pointer at a value corresponding to the appropriate level. A count of "four" on Trial One, for a given item, indicated a response latency of about two seconds, and a count of "three" a response latency of about one second. The dial settings that corresponded to the various "counts" that could be obtained were listed on a card. When the count for a given item on Trial One was "three," E set the dial so that on Trial Two this same item would appear at about threshold visibility. When the count on Trial One was "four," E set the dial to present RT on the next trial at a visibility level roughly midway between threshold and full intensity. When the count on Trial One was "five" for a given item, the prompt for that item on the next trial was given at full intensity. Thus, the faster a subject responded to a prompt on any given trial from One to Four, the weaker the prompt provided on the next trial; the longer S's response latency on a given trial, the stronger the prompt for the item on the following trial.

The control condition included a regular first trial. On Trials Two, Three and Four, ST was presented for three seconds and then RT was exposed fully for five seconds. Under both conditions, the final (fifth) trial was a test using the regular 8-Second Anticipation procedure with the cards in mixed order.

Results of Experiment V

The mean number of items correct on the test trials under the two conditions was 13.1 for the experimental condition and 12.25 under the control condition. Two Ss performed better under each of the conditions. The difference in means is not statistically significant by a t-test for repeated measures on the same subjects. Because all of the Ss in this experiment repeatedly did anticipate, although instructed not to do so, the count data could not be used.

EXPERIMENT VI

The final experiment in this series was undertaken to compare the efficacy of the experimental and control conditions used in Experiment IV, with an additional control condition. This additional control condition consisted in an immediate full prompt, or "study" condition. A further change in the experimental procedure was to require all Ss to learn four instead of two lists a day for two days.

Thus, a total of four Ss learned eight lists, of which four lists were learned under the condition of QF-8 with Progressive Opportunity to Respond (QF-8-P), two lists were learned under the regular 8-Second Anticipation condition and two lists were learned under an Immediate Full-Prompt condition.

Experimental Design and Procedure

To provide some counterbalancing for the three conditions to be used, each S learned two experimental and two control lists each day. The order in which the control lists were introduced was counterbalanced so that each control condition was used twice with the first list learned, twice with the second list learned and so on. The order of the actual lists was only partially counterbalanced. The procedures with each S were the same as those previously described except for the introduction of a new set of instructions appropriate to the Immediate Full-Prompt condition. Four additional lists were made up for this experiment. They were constructed in the same way as the earlier lists.

Results of Experiment VI

Figure 5 shows the total number of items correct on the test trials under each condition on each day. Following an approximate test for homogeneity of variance (Edwards, 1954), which indicated that variances within the three conditions were alike, a three-part analysis of variance was made. Table 3 shows the summary of this analysis, which indicates that the differences among the means for the three conditions are unlikely to have occurred by chance. When t-tests for repeated measures on the same subjects were made to test differences between scores under the three conditions, the

Table 3

Summary of the Analysis of Variance, Experiment VI

Source of Variation	DF	Mean Square	F	P
Between Conditions	2	131.32	30.4	.01
Between Subjects	3	14.57	3.37	n.s.
Residual	6	4.32		
Total	11			

differences between the Immediate Full-Prompt condition and the 8-Second Anticipation condition both yielded P-values of $<.05$. (The

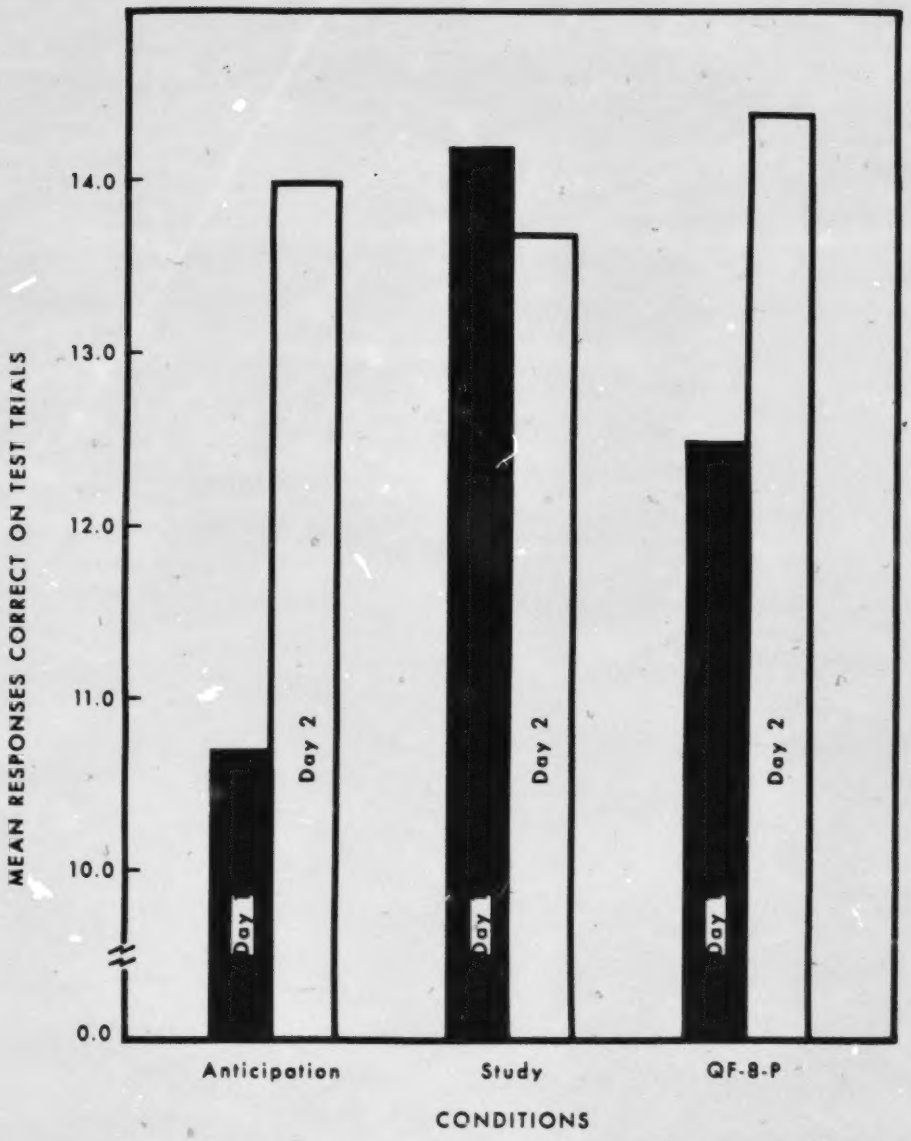

Fig. 5. Correct responses on test trials on Days 1 and 2.

apparent superiority of the study condition over the QF-8-P condition for Day 1 shown in Figure 5 was not shown to be statistically reliable.)

Figure 5 shows that differences in performance under the three conditions tend to be larger on the first day than on the second. Thus, as practice is increased, whatever effects the conditions are having appear to wash out. When separate analyses of variance were performed on the first and second days' results, only the first day's results were statistically significant ($P < .05$).

SUMMARY: EXPERIMENTS I-VI

Table 4 presents a summary of the comparisons made in the six experiments in which some form of partial cueing was pitted against

Table 4. Summary of Comparisons for the Six Experiments between Experimental (Partial-Cueing) and Control (Standard Anticipation/Confirmation) Conditions

	Expt. #	(# of lists, trials)	N	Experimental Conditions*	Test-Trial Results**
Variable-Intensity-Cue Comparisons	I	(4, 6)	4	FI-6: E-controlled fade in	+0.1
	I	(4, 6)	4	FI-8: E-controlled fade in	+1.4
	II	(4, 6)	2	VFI: S-controlled fade in	---
	III	(4, 5)	4	FI-8-P: Progressively longer time before FI cue	+1.1
	V	(4, 5)	4	Variable intensity depending on preceding trial for each item	+0.8
Tachistoscopic-Cue Comparisons	I	(4, 6)	4	QF-6) Quick flash of RT at fixed time; no ready signal	-1.1
	I	(4, 6)	4	QF-8) Quick flash of RT at fixed time; no ready signal	+0.25
	II	(4, 6)	2	QF-8-H: Ready signal, QF; response held	(+)
	III	(4, 5)	4	QF-8-H: Ready signal, QF; response held	+0.7
	III	(4, 5)	4	QF-8-P: Progressively longer time to try to anticipate before QF	+0.9
	IV	(4, 5)	8	QF-8-P: " " "	-0.2
	VI	(4, 5)	4	QF-8-P: " " "	Day 1: +1.8 (Day 2: +0.4)

* "FI" means fade in of response cue, "QF" means quick flash of response cue: see text. Control condition was a standard anticipation method except that in Experiment VI a full-prompt "study" condition was also employed.

** Approx. mean difference favoring (if positive) the experimental (partial-cueing) condition over control (anticipation/confirmation) condition.

a corresponding control condition. It may be noticed that of 12 separate comparisons between cueing methods and anticipation conditions, nine of the comparisons favor the cueing method over the control method. In one instance there is no appreciable difference in obtained measures, and in two instances the scores for control conditions were superior by statistically insignificant amounts. However, when a study (full prompt) condition was used as a control (Experiment VI), the study condition was also superior to the anticipation condition and tended to be superior to the partial-prompt condition, though not reliably so.

One further comparison may be worth noting, taking into account the three experiments (III, IV and VI) which employed the procedure of a tachistoscopic (Quick Flash) cue which was progressively delayed on successive trials to allow progressively greater lengths of time for S to respond prior to prompting. While Experiment VI was not an exact replication of the QF-8-P condition used in Experiments III and IV, the modification was relatively small. Instead of learning four lists in two days, Ss in Experiment VI learned eight lists in two days: on the first day, two lists under the QF-8-P condition, and one list under the 8-Second Anticipation condition (as well as one list under an 8-Second "Study" condition)--with these conditions then repeated, in partially counterbalanced order, on the second day. Thus the two changes included further practice and possible interactions between conditions. Before pooling the data for the control and QF-8-P conditions for the three experiments, two separate analyses of variance were made, one for the three sets of scores under the QF-8-P condition and one for the corresponding three sets of control scores. Neither of these separate analyses yielded large enough values of F to reject the null hypothesis. The data for the two conditions for all 16 Ss in the three experiments were then pooled and a three-part analysis of variance was made. Table 5 shows the summary of this analysis.

The F-ratios for Column and Row effects are significant at the .01 level. The actual magnitude of the difference is small. The mean number correct on test trials under experimental conditions

Table 5

Summary of Analysis of Variance

Pooled Data for Experiments III, IV and VI

Source of Variance	Df	Mean Square	F	P
Between Conditions	1	2.16	12.34	< .01
Between Ss	15	14.25	81.42	< .01
Residual	15	.175		
Total	31			

was 12.76, while the mean under the control condition was 12.25. Examination of the pairs of means for the 16 individual Ss in this combined group shows that 10 of the 16 Ss performed better under the experimental condition, one performed equally well under both conditions and five performed better under the control condition than under the QF-8-P condition.

Discussion

Although the number of subjects per each condition was small within each of the six experiments, the stability of the results was enhanced by several factors. First is the fact that each S learned at least two lists under control conditions and two under experimental conditions within each experiment (four lists for each condition in the final experiment). Thus, as each subject served as his own control, individual-difference variability (which under other conditions would have required considerably larger N's to achieve reasonable stability) was to a large extent removed as a source of error. In addition, variability due to differences in material and to practice effects was to a considerable extent controlled, both by the fact that each S learned more than one list under each condition and by the counterbalancing of lists and order of testing for control and experimental conditions within each experiment. Finally, as seen in the Summary of Experiments I-VI, the essential aspects of some of the main comparisons were replicated across several experiments.

Even so, the results of the experiments do not provide striking evidence to support the hypothesized advantage of partial cueing, for facilitating paired-associate learning, as compared to paired-associate learning under standard anticipation conditions. However, the partial-cueing hypothesis should not be rejected summarily. In only one of the single comparisons was a cueing method superior to its anticipation control method to a degree that achieved statistical significance; but in nine of the twelve experimental comparisons in which partial cueing methods were compared with anticipation methods, the results favor the cueing methods. Also, when the data of all Ss run under one of the cueing methods (Quick Flash with Progressive Increase in Time Allowed to Anticipate) were pooled, statistically reliable superiority over the control condition remained. It can be concluded that while the partial-cueing methods used did not produce any large facilitation in paired-associate learning, some small effect was probably present.

However, on the basis of the significantly better performance of Ss in Experiment VI tested under the "Study" condition than when tested under the anticipation control condition, a possible interpretation is that immediate, full prompting may frequently represent an optimum condition, and that the various partial-cueing methods simply provided varying approximations to this immediate, full-prompt condition. In any case, two questions must be raised. The first is the methodological question of what condition is the best base against which to compare various cueing methods. The second is the more basic question of whether--or, rather, under what conditions, if any--it should be advantageous to use some form of partial prompting rather than using full, complete prompting (as exemplified in the "Study" condition).

The results of Cook and Kendler (1956) and Cook (1958) are relevant to both questions. Their results favored prompting (or, actually, a mixture of prompted trials and unprompted test trials) over anticipation or "confirmation" conditions. Further, the results of Angell and Lumsdaine (1960) favored a mixture of prompted and unprompted trials over "pure" prompting conditions. In view of these findings, the pure-prompting or study condition might, from

the standpoint of methodology, be taken as the baseline from which further exploration of the advantage of partial prompting might proceed. Nevertheless, anticipation/confirmation conditions were instead used as the control baseline in the present experiments. The decision to do this was made partly in order to provide data for latency and correctness of anticipatory responses during acquisition, and partly because it was felt that the greater expected advantage of partial cueing over anticipation/confirmation would provide a more sensitive and hence more efficient kind of comparison with which to explore various partial-prompting techniques. Of the techniques tried, only the most likely one (Quick Flash with Progressive Amount of Time Allowed for Anticipation Prior to Cueing) was then also compared--but not, as it turned out, to its advantage--with the fully prompted or "Study" condition.

Turning now to the second and more basic question, let us assume (on the basis of the present data and previous findings) that some form of prompting--partial or complete--is potentially superior to no prompting (i.e., the customary anticipation/confirmation condition). The question is then to determine the conditions under which one form--complete prompting, or some form of partial prompting--will be superior to the other.

That something less than full prompting should be advantageous at least part of the time is implicit in the notion of vanishing and is given empirical support not only by the results of Angell and Lumsdaine (1960) for paired-associates, but also, in the case of procedural learning, by the findings of Maccoby and Sheffield (1958). The former show only that a mixture of prompted and unprompted trials is superior to 100% prompting; the latter go further in showing that, under some conditions at least, transition from more direct prompting early in learning to less direct or immediate prompting later on can be superior to continued use of full or direct prompting. But the lack of any evident superiority for the partial-prompting over a full-prompting (or "study") condition in Experiment VI of the present study suggests strongly that we have not as yet found dependable ways for implementing the potential advantages of partial cueing. The same conclusion may be drawn from

the study by Angell and Lumsdaine (1961a), in which attempted techniques for providing partial prompts were not shown to be superior to anticipation/confirmation procedures. Thus at a minimum we must conclude that the potential advantages of partial over full prompting cannot be expected to materialize except under conditions which we are as yet unable to specify with any precision.

However, the rationale for expecting partial cueing to be superior to full prompting might imply that this superiority could be most clearly manifested:

1) Under conditions of delayed testing, when the advantage of having practiced without cue support are most needed because the test situation is far removed from the prompting effect of preservative, "echoic" or "reverberating" implicit responses carrying over from the practice in the acquisition situation;

2) Under conditions where, during acquisition, there would be a tendency for daydreaming or distraction from the task, so that required responding to an incomplete cue insures that relevant responding does occur; this would imply a lengthy unpoliced study period rather than a short one in which maximal attention is imposed in an experimenter-monitored situation;

3) Where response learning is not required, so that the response can be readily given if a cue is present that trips it off;

4) Where a faint and/or brief representation has distinctive cue properties that differentiate it from other RTs; and/or

5) With the use of a partial-cueing technique which does not introduce distracting elements or irrelevant response tendencies that interfere with activities conducive to learning.

Some light on the last of these conditions may be shed by comparing the features of the two principal partial-cueing techniques tried out in the present study. The relative merits of these two (Fade-In versus Quick Flash conditions) cannot be assessed directly, though a significant advantage over anticipation conditions was demonstrated only for the QF (tachistoscopic) condition. A hypothetical advantage might be suggested for the latter method in terms of S's set during the cueing interval. The difference here might be illustrated by the lone wilderness camper who is listening

because he thinks he hears "something," and the camper who is listening for the return of a friend. In the QF conditions used, the cue was always presented at such strength that S could read it provided he were looking in the right place. Under the Fade-In conditions, Ss often could not "say" the letters until the cue was at nearly full strength.

Israel (1960a) has shown that in paired-associate learning the stimulus term actively contributes to the probability of identifying a blurred image of the response term. While Israel's study did not compare the relative efficacy of cued versus uncued learning, his results suggest indirectly that cues should facilitate learning. However, the main task his Ss were given was that of identifying the blurred image. In the cueing situation in the present experiments, on the other hand, S's task was to give the correct response without having to identify the cue--and, eventually, without requiring a cue at all. If "looking for the cue" or trying to identify the cue subtracts from the amount of time S has in which to relate ST and RT through some private, mediating response, then forms of cueing which require such "looking for" behavior may in fact reduce learning rate in comparison with immediate full-prompt conditions.

Several improvements that could be made in the procedure used in the present study might be of value in further use of fade-in techniques. One that is clearly apparent would be to increase the range of cue strength possible with the viewing apparatus. Israel (1960b) has presented a series of photographs illustrating the range of cue values possible with his blurred image technique. This range considerably exceeds that which was readily obtainable with the backlighting arrangement used here. A second improvement might be to make the cued items, e.g., the codes, more varied by typing or printing them in upper and lower case type. Since pattern or profile appears to be an important ingredient in word recognition, such a change would tend to enhance the distinctiveness of each code. A third improvement, and one that is clearly indicated by our data, would be the inclusion of a more accurate means of measuring the latency of Ss' responses--e.g., use of a voice-

key arrangement. Finally, it seems likely that a combination of tachistoscopic presentation of successively less distinct cues, combining the quick-flash and indistinct-cue technique, might capitalize on the advantages of each.

Some observations made by some of our Ss are also relevant to the question of possible distractions introduced by attempts at partial cueing. In response to the question "How did you learn the lists?" a majority of Ss responded that they had tried to "link" ST and RT by forming some meaningful or amusing connection between the two, or had looked for physical similarities between city name and code. If this is in fact what most Ss do when confronted with a paired associate task, then increasing the opportunity to study both ST and RT together should aid this activity. While this method has tended to be little used by psychologists because it provides no measure during acquisition, it may in fact represent a good technique for presenting materials.

If, furthermore, the association does benefit greatly from some kind of mediating response in order to produce RT, when ST alone is presented, an interesting technique to try would consist in providing such mediators for S (somewhat like the mediating cue-words found by S. Pan (1926) to facilitate the learning of paired-associate terms). For example, one of the more difficult pairs in the present study was YZT as the code for Port Hardy, British Columbia, Canada. Several sources of difficulty are apparent. While both "t" and "y" are found in the stimulus term, they are not in the same order as in the code. The letter "z" is missing entirely. Nor is there any obvious, meaningful abbreviation in the code. If, now, the silly phrase Yellow Zebras Thrive is inserted between the code and the city name, a link of the sort used by many Ss is provided. Perhaps a better means of setting up such links would be to make up a single list of all the stimulus and response terms and have preliminary Ss give their immediate associations to the terms. These associations could then be used to provide a source of "links" for the later paired-associate task. Presumably these links could be vanished as Ss began responding without them.

Finally, it might be rewarding to compare the relearning of

material under cued and uncued conditions. If paired-associate learning is largely an all-or-none affair, as some of the data described by Estes (1960) suggest, it might be expected that original learning would proceed most rapidly under some form of immediate full prompting. Once material has been learned, but has weakened as a result of subsequent interfering responses, the weakened behavior could be strengthened by cueing. This possibility harks back to the original use of the term redintegration. A fraction of the stimulus pattern originally required to produce a response now becomes adequate. It seems possible that the maximum advantage of partial cueing might occur in this relearning situation rather than in origianl acquisition where this need for full or nearly full prompting for any given item may often continue until close to the point of initial mastery.

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